

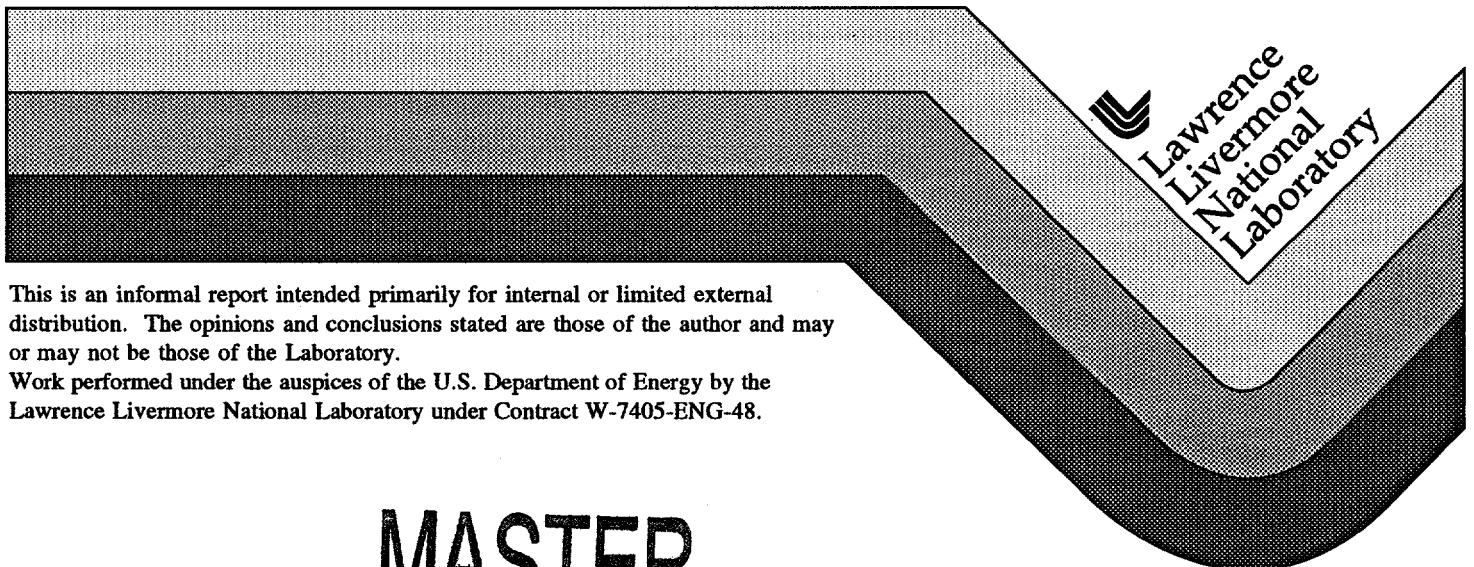
Weaknesses in Bethe's Theory of Seismic Coupling

J. Nuckolls

RECEIVED
APR 14 1997
OSTI

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED *ph*

April 6, 1959



This is an informal report intended primarily for internal or limited external distribution. The opinions and conclusions stated are those of the author and may or may not be those of the Laboratory.

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

MASTER

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This report has been reproduced
directly from the best available copy.

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (615) 576-8401, FTS 626-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.,
Springfield, VA 22161

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

April 6, 1959

MEMORANDUM

TO: Distribution

FROM: John Nuckolls

SUBJECT: Weaknesses in Bethe's Theory of Seismic Coupling.

**DECLASSIFICATION
STAMP ON REVERSE.**

Quantitatively, Bethe's theory is in error by a large factor. It may also be qualitatively wrong. Several major weaknesses are outlined below:

1. Equation of state in the hydrodynamic region.

Bethe uses an equation of state which approximates the initial shock Hugoniot. Since the shock changes entropy and the subsequent expansion is nearly isentropic, the adiabat and the Hugoniot do not coincide. Within approximately 75 feet of the Rainier explosion, Bethe's equation of state overestimates by about a factor of two the energy deposited as waste heat by the shock wave.

2. The fractured region.

Bethe does not correctly treat the region between $\sim 130'$ and $\sim 250'$ (from Rainier) which is neither elastic nor plastic. The initial motion before the Tuff goes into tension (compressive stress due to overburden is exceeded) is approximately elastic. This transient elastic motion reduces the scalar radial momentum (proportional to the impulse subsequently applied to the elastic region). Thereafter, since no large scale tensile stresses can exist and the radial stress is compressive and non-zero, the stress-strain relation is very complicated. Even if the fractures are on a small scale relative to the shock radius, it is not correct to set the shear modulus to zero (i.e., make the stress a scalar) and use a fluid type equation of state (e.g., sand supports a weight).

Classification (Classification/Review Date) Changed to:

UNCLASSIFIED

(Insert appropriate classification level or indicate Unclassified)

by authority of R2D2-10749 6/27/96 (date)

(Authority for change in classification, e.g., the memorandum number.)

by [Signature] 10/1/96 (date)

(Signature of person making the change)

verified by [Signature] 10/6/96 (date)

(Signature of person verifying this is the correct document or model)

3. Elastic region.

Bethe assumes that when the peak shock pressure is less than ~.5 kb, the Tuff behaves elastically. Actually Tuff probably has no tensile strength on a large scale. Elastic behavior can occur only when the compressive stress due to the overburden is not exceeded. (Other rocks may possibly have some large scale tensile strength, but it is probably less than the stress due to 1000' of overburden.) The "strength" of materials depends upon stress rate, pressure, size of sample, and local stress concentrations.

4. Non-linear attenuation.

By the use of Fourier analysis to find the low frequency component Bethe implicitly assumes that attenuation is by a linear physical process. There is evidence that this process is non-linear. Energy may therefore be transferred from high to low frequencies.

The HE and nuclear experimental programs may be expected to produce some surprises.

Distribution:

F. Adelman
H. Brown/J. Frank
J. Tracy
W. Futterman
W. Hekrotte ←
R. Herbst
E. Teller
C. Violet
J. Lepore
D. Griggs
A. Latter
J. Nuckolls
File (2)